Broadening the Scope of Protein Research with Tektronix Test and Measurement Instruments

Solution Summary

Challenge	Research protein behavior by applying an electrical signal to a protein sample and characterizing the molecular response.
Solution	Tektronix AFG3252 Arbitrary/Function Generator, in combination with a Tektronix TDS5104B digital phosphor oscilloscope and National Instruments' LabVIEW software.
Benefits	The AFG3252 delivers unparalleled test flexibility thanks to a broad frequency range and two channels with extremely well aligned frequencies and phases at an affordable price. Seamless interconnection between the AFG3252, TDS5104B and LabVIEW provide correlated measurements and graphical views of both input and output signals.

Constituting roughly 25 percent of living matter—from bacteria to plants to animals—proteins are essential to all life processes. Not surprisingly, they are some of the most commonly studied biological molecules. Traditional methods of protein research, however, such as X-ray Crystallography and Nuclear Magnetic Resonance, can be limiting. The former merely provides a static snapshot of atomic positioning within a protein, while the latter only offers information about a minute slice of a protein, often a single atom and its immediate chemical environment.

Infinite Quanta Inc., a non-profit scientific research organization, is striving to broaden the scope of protein research to overcome these limitations. The organization is developing new, non-standard ways to study proteins: in their entirety and in an active state.

“Proteins are relatively large molecular structures and possess their own electric fields,” said Dr. Stephen Lukacs Jr., President of Infinite Quanta. “By studying these electric fields, we can gain new insight into the nature and dynamics of proteins.”

Keys to this research are “dipole moments,” which are created by electrical charges within a protein. By stimulating, measuring and characterizing these dipole moments, Infinite Quanta is able to study the resonance harmonics, inter- and intramolecular interactions and motions of proteins.

Known as “dielectric spectroscopy,” the study of electric fields interacting with molecules has been in practice for more than a century. According to Dr. Lukacs, however, electrical instrumentation with sufficiently high frequency bandwidth and noise rejection has not been available to stimulate and accurately measure protein behavior—until now.

“Modern instrumentation offers the potential for observing larger structural domains within macromolecules, or even whole molecular responses and processes,” Dr. Lukacs explained. “It is opening up an entirely new realm of protein research.”

> **“We’re finding things that nobody has ever seen before.”**
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> -Dr. Stephen Lukacs Jr., President and Principle Investigator, Infinite Quanta Inc.

Tektronix AFG3252 and TDS5104B Create “Perfect Test Set”

Disenchanted with the narrow frequency range and high cost of spectrometers and lock-in amplifiers that would typically be employed to produce and measure electrical currents within a molecule, Infinite Quanta sought an alternative solution.

“We found general purpose test and measurement instrumentation from Tektronix to be better suited to dielectric spectroscopy than specialized research equipment intended for such tasks,” Dr. Lukacs noted. “They deliver the performance and functionality required for advanced protein research, and at a price suitable for a non-profit research organization.”

Infinite Quanta is utilizing a Tektronix AFG3252 Arbitrary/Function Generator to apply a sine wave and electrically stimulate protein samples, and a Tektronix TDS5104B digital phosphor oscilloscope to measure the molecular response.

“It’s the perfect test set,” said Dr. Lukacs. “The AFG3252 provides a broad frequency range for test flexibility. It also offers two channels, which enable us to compare a reference signal with a sample signal, or study multiple samples at once.”

Channel-1 of the AFG3252 outputs a reference signal directly into the TDS5104B oscilloscope. Channel-2 of the AFG3252 outputs to a custom capacitive sample cell to measure the dielectric response of peptides and proteins, which is simultaneously fed into another channel of the TDS5104B. The two signals are concurrently processed to transform the sample signal into a frequency-locked magnitude and phase measurement of the sample.

“The two instruments are seamlessly interconnected,” Dr. Lukacs added, “giving us correlated measurement results with an impeccable view of the waveforms. We’re finding things that nobody has ever seen before.”

Infinite Quanta uses National Instruments’ LabVIEW software to interface and control the AFG3252 and TDS5104B test set. Frequency is manipulated to measure the magnitude and phase of the sample signal under various conditions. The software’s frequency-locked computations reject noise outside the user-defined frequency to convert the oscilloscope into a more sensitive detector. These highly sensitive dielectric measurements lead to dielectric spectra of dipole responses of peptides and proteins.

Dr. Lukacs indicated both channels of the AFG3252 are critical to these experiments since independent signals are required to ensure that the reference signal is not influenced by the impedance of the sample circuit. Although both channels are electronically separate, the fact that the waveforms are derived from the same internal clock ensures that the signals are exceptionally well aligned in frequency and phase. This is essential for the frequency-locked computations and transformations.

Infinite Quanta is currently using sinusoidal waveforms with a frequency range of 1 mHz to 240 MHz. The voltage amplitudes are set at 50 mV, and the frequencies are incrementally swept to create a dielectric spectrum using LabVIEW. Infinite Quanta intends to use square-wave and voltage-stepping in the future.

“The primary challenge is presented by the purity of the electronically separate signals of the two channels, but linked to a common clock and controller for phase and frequency exactness between the two output channels,” Dr. Lukacs explained. “The AFG3252 perfectly performs this task to less than 0.05 degree phase difference of the two channels at 100 Hz.”

According to Dr. Lukacs, the AFG3252 was the only instrument up to the challenge. “The Agilent 33250A and the Fluke 396 arbitrary function generators were tested against our requirements and the divided single output created significant errors in our measurements,” he said. “The AFG3252 completely solved our requirement for two separate yet linked output channels and signals, while providing a broader frequency range and better stability.”

10/06 75W-20127-0